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Abstract

This study investigated the effects of analogy in remediating senior secondary school students' misconceptions in photosynthesis in Ikare, Ondo State, Nigeria. A quasi-experimental design of pre-test, post-test control group was adopted for the study. The sample of the study consisted of 108 senior secondary school II biology students from two co-educational schools. The two schools were randomly classified into control and experimental group. Analogy of cake baking processes was used as instructional strategy for the experimental group while the control group was taught using the conventional method. Photosynthesis Misconceptions Test (PMT) with a reliability co-efficient of 0.74 was the instrument used for data collection. Frequency and Chi-square were used to analyze the data collected and findings revealed that biology students in senior secondary school held misconceptions in photosynthesis and analogy as an instructional strategy was able to remediate biology students' misconceptions in photosynthesis than the convectional method of instruction. Based on the findings, it was recommended that, biology teachers should endeavour to first identify students' misconceptions in photosynthesis and employ appropriate instructional strategies such as analogy to remediate such misconceptions.

Introduction

Misconceptions had been well established as a common factor that interfere with learning among students. Often, most misconceptions are resistant to change even after being confronted with the conventional method of teaching (Luwoye, Bello, & Adeoye, 2021; Ogundare, Bello, Adeoye, & Abimbola, 2020; Svandova, 2014). A conceptual view of misconceptions indicates that it has peculiar explanations, interpretations and meanings which do conform with scientifically accurate explanations (Bahar, 2003). Misconception as a term can be more appropriately defined as the conception of an individual that departs significantly from the publicly held version of an aspect of knowledge domain or concept which could arise from certain experiences which are usually shared among individuals (Adegboye, Bello, & Abimbola, 2017; Svandova, 2014).

Misconceptions usually begin during the early stage of life and education of every individual due to differences in cultural backgrounds and beliefs (Akolade, Adeoye, Ayanda, & Abimbola, 2020). For instance, children at the elementary level are taught that sunlight, water, and soil are needed for plants to grow. This simple explanation of plant's growth and nutrition leads to misconceptions because students tend to belief that plant food comes from the environment and not through the process of photosynthesis. These misconceptions and many more often persist in learners' understanding of photosynthesis because molecules involved in the process of photosynthesis are invisible to the naked eyes and it is also hard to analyse the results of photosynthesis, since plants grow at seemingly slow rates (Tlala, Kibirige & Osodo, 2014).

The concept of photosynthesis is perceived as a difficult concept at the senior secondary school level of education owing partially to misconceptions of some important photosynthetic concepts (Ahmed & Lawal, 2020; Haruna, 2021; Yuliasari, Hari, & Marianingsih, 2023). Its difficulty is based on the complex biological process consisting of ecology, physiology, biochemistry and autotrophic feeding whose connection cannot be easily understood by students. Photosynthesis as a fundamental process for life on earth has long been a core part of school Biology curriculum (Metioui, Matoussi & Trudel, 2016).

Photosynthesis is the process by which green plants manufacture their food using sunlight as the main source of energy (Umeh, 2015). Photosynthesis has also been defined as the biological process employed by plants, algae, and certain bacteria to produce nourishment by absorbing carbon(iv)oxide and water from their surroundings, including the atmosphere and the soil (Bally, Marinović & Nikolić-Lukovska, 2023). From the foregoing, photosynthesis can be defined as the process by which green plants manufactured carbohydrates or sugars using chlorophyll combined with carbon (iv) oxide and water in the presence of sunlight energy, while oxygen is given out as a by-product. Photosynthetic process is vital in life, not only to plant but to animals since animal depend on plants for their food either directly or indirectly. Therefore, teachers need to adopt or adapt appropriate strategies that can communicate the underlying concepts of photosynthesis effectively to learners (Adeoye, Bello, & Abimbola, 2022).

Analogy as an instructional strategy has been found to be effective in assisting students to build understandings either through hands-on interactions with tangible resources (Richland & Simms, 2015) or by making conceptual links with familiar objects, scenarios or events (Haglund, Jeppsson, & Andersson, 2012). Analogy involves the comparison of an unfamiliar situation or things with the familiar so as to boost understanding (Ruhi, 2003). Also, Nawaf (2016) described analogy as a way of describing the comparative relationship between two sets of terms which are usually related to each other. Abimbola (2013) defined analogy as a method of describing things that are not known in terms of things that are known. It is a way of describing things they see in terms of what they had not seen before, in their resemblance so that understanding can be achieved. Also, Calik and Ayas (2005) believed analogical reasoning involves the transfer of schema from a familiar situation into an unfamiliar situation, such that analogies can make individuals to acquire useful insight into unfamiliar domains.

Mohammed, Odeniyi, Ameen, and Yusuf (2023) posited that analogies serve as valuable aids in the instruction of complex scientific ideas and can help rectify misunderstandings among learners. Nevertheless, when employed incorrectly, they have the potential to exacerbate misconceptions. Analogy can take various forms, such as a diagram, a real-life scenario, a cartoon, an allegory, a parable, a pair of words with similar relationships, a metaphor, a game, a paper craft, a mime performance, an animation clip, or any creative creation by an imaginative teacher, all designed to actively engage students and help them grasp a concept (Ballard, 2011). As described by Maharaj-Sharma and Sharma (2015), an analogy comprises two essential components: the analog, which represents a familiar object or situation, serving as a model for learners to draw assumptions and conclusions on new or unfamiliar situation or object known as the target. For instance, in an analogy explaining the structure of an atom, the target represents the structure of an atom, while the analog is akin to the planets' arrangement.

Several studies such as those of Ahmed, Sulaiman, & Adeoye (2015), Ayanda (2016), Mohammed, Odeniyi, Ameen, and Yusuf (2023) have revealed the effectiveness of analogies at improving the biology achievement of senior school students' when compared with conventional method of teaching. In addition, Dilber and Duzgun (2008) conducted a study on the impact of using analogies in teaching compared to traditional instruction methods on students' academic achievement and the correction of misconceptions. The study involved 78 high school students, approximately 15-16 years old, who were enrolled in an introductory physics course. Participants were divided into two classes, with one class randomly assigned to the control group and the other to the experimental group. During the instruction of electric concepts in the physics curriculum, the experimental group received analogical instruction, while the control group received conventional instruction. The findings demonstrated that students in the experimental group outperformed their counterparts in the control group in terms of their understanding of electric concepts.

Obiajulu and Ezekwike (2019) evaluated the impact of employing analogies on the academic performance of Biology students. Two research queries directed the investigation. The study adopted a quasi-experimental research design and targeted a population of 520 students. The study's sample size comprised 64 students. Data was collected using Biology Achievement Test (BAT), and data analysis involved calculating means. Additionally, hypotheses were tested using t-statistics. Findings of the study indicated that students who were taught Biology concepts using analogies achieved better results compared to those who were taught without the use of analogies. The present study also attempts to find out the effects of analogy in remediating senior secondary school students' misconceptions in photosynthesis with a view to identifying such misconceptions and remove ng them permanently.

Purpose of the Study

The main purpose of the study is to investigate the effects of analogy as an instructional strategy in remediating senior school students' misconceptions in photosynthesis in Ikare, Ondo State. Specifically, the study investigated the difference in the number of misconceptions held by biology students when taught photosynthesis using analogy and those taught without analogy.

Research Questions

In this study, the research question what the difference in the number of misconceptions held by biology students is when taught photosynthesis using analogy and those taught without analogy was answered.

Research Hypothesis

H_0: There is no significant difference in the number of misconceptions held by biology students when taught photosynthesis using analogy and those taught without analogy.

Methodology

Quasi-experimental design which involved the pre and post-test non-randomized experimental and control groups was adopted for the study. The pre-test and post-test were administered to identify the number of misconceptions held by students before and after exposure to the treatment. The population consisted of all senior secondary school students Ikare Akoko, Ondo State while the target population consisted of senior school two students. The sample comprised 108 biology students who were selected using random sampling techniques.

Two research instruments Analogy Instructional Package (AIP) and Photosynthesis Misconception Test (PMT) were used for data collection. Analogy Instructional Package (AIP) served as the treatment for the experimental group and was used by the researchers to introduce the analogy of the process of baking cake to the students. Photosynthesis Misconception Test (PMT) consisted of two sections A and B. Section A was concerned with the respondents' demographic information while section B consisted of twelve open-ended short response questions. The Photosynthesis Misconception Test (PMT) was subjected to face, content, and construct validity by giving copies of the instrument to three experts in the field of science education. In addition, the reliability of PMT was determined by using the test-retest method involving an intact class of students in a school that did not participate in the main study and a reliability Coefficient of 0.74 was obtained using Pearson Product-Moment Correlation Statistics at 0.05 alpha levels of significance.

To commence the process of data collection and treatment administration, the Photosynthesis Misconception Test (PMT) was administered as pre-test by the researchers before the first lesson to identify misconceptions held by students in terms of their number and nature. This was followed by treatment administration in which the experimental group was taught photosynthesis using the process of cake baking as analogy for instruction while the conventional method of teaching was used for the control group. The last week of teaching was used to administer the post-test that contained the same but reshuffled items as the pre-test to ascertain the effect of the treatment on remediating students' misconceptions. The data collected from pre-test and post-test of both the experimental and control groups was analysed using frequency to analyse the research question and Chi-square for hypothesis testing. All analysis was carried out at 0.05 level of significance using the Statistical Package for Social Science.

Results

Research Question: What is the difference in the number of misconceptions held by biology students when taught photosynthesis using analogy and those taught without analogy?

Table 1 shows the number of identified misconceptions in photosynthesis among biology students for both the experimental and control group before and after instruction in each question. Students in the experimental group held 132 misconceptions, while the misconceptions held by students in the control group were 143. This shows that there was a slight difference between the two groups but after instruction, the number of misconceptions held by students in the experimental group reduced considerably compared to the control group (experimental group 65 and control group 111). It is therefore indicated that 67 misconceptions were remediated in the experimental group, while in the control group, 32 misconceptions were remediated. This implies that analogy as an instructional strategy remediated misconceptions held by biology students in photosynthesis.

Table 1

Contingency Table for the Number of Misconceptions for both the Experimental and Control group before and after instruction in each question.

Group	Test	Items													No remediate
		1	2	3	4	5	6	7	8	9	10	11	12	Total	
Experimental	Pretest	11	21	13	12	8	10	9	8	9	12	10	9	132	67
	Posttest	7	13	6	8	5	4	7	2	6	3	2	2	65	
Control	Pretest	17	18	8	14	12	6	14	5	17	10	13	9	143	32
	Posttest	12	18	11	13	7	9	10	5	12	5	4	5	111	

Research Hypothesis: there is no significant difference in the number of misconceptions held by biology students when taught photosynthesis using analogy and those taught without analogy.

The Chi-square result in Table 2 indicates that there was no significant difference in the number of misconceptions held by biology students taught photosynthesis using analogy as an instructional strategy and those taught without analogy as an instructional strategy ($x^2_{(2,117)}$ =12.02, $p > 0.05$). This affirms the fact that misconceptions are resistant to change even after being confronted with analogy as an instructional strategy.

Table 2

Chi-square Analysis of Difference in the Number of Misconceptions Held by Biology Students in the Experimental Group and Students in the Control Group

Group	Observed	Expected	N	df	Cal. Value	Table Value	Sig	Remark
Experimental	65	88	51	117	12.02	143.27	NS	Not Rejected
Control	111	88	67					

Discussion

The present study investigated the effects of analogy in remediating senior secondary school students' misconceptions in photosynthesis and has revealed that students holds misconceptions before and after instructions. Although, the instructional strategy used in the study remediated some of the misconceptions held by the student, however, some of the identified misconceptions were resistance to change even after treatment. This may be due to the nature of photosynthesis which requires practical activities without which abstractions in instructions may not be fully eliminated. In addition, most of the students could not use appropriate terminologies and expressions in their responses to questions. This finding was in congruent with the studies of Ogundare, Bello, Adeoye, and Abimbola (2020), Novak (2003), and Burgoon, Heddle and Duran (2011) which affirms the existence of misconceptions in teaching and learning.

The study also showed that analogy is more effective in remediating biology students' misconceptions in photosynthesis compared with conventional instructional strategy despite the lack of significant difference in the number of misconceptions held by biology students taught photosynthesis using analogy and those taught without analogy as an instructional strategy. This may be because those misconceptions might have been held by the students for a considerable period of time thereby made it difficult to be remediated easily. This is in agreement with the study of Dilder and Duzgun (2008) who remarked that analogies promoted profound understanding of complex scientific concepts and they help students to overcome their misconceptions. Also, Nwankwo and Madu (2014) established that student taught using analogy model in an experimental out performed those taught same concepts using conventional lecture method. It is also in line with the work of Parker et al (2012) and Svandova, (2014) who established that most misconceptions among students are resistant to change and therefore interfere with subsequent learning.

Conclusion

The outcome of this investigation showed that senior secondary school students held misconceptions in photosynthesis and the use of analogy as an instructional strategy was relatively more able to remediate students' misconceptions than convectional instructional strategy. Although, it was observed that analogy as an instructional strategy did not remediate all the misconceptions held by students, hence, the non-significance of the difference between the number of misconceptions held by the experimental and the control groups.

Recommendations

Base on the findings of the study the following recommendations were advanced.

i. Biology educators need to make sure that they constantly identify students' misconceptions, before, during and after each lesson, thus, use suitable teaching approaches like analogy to remediate such misconceptions.

ii. biology textbook authors should be aware of misconceptions in photosynthesis and introduce analogies that are familiar to the students, to present the topics.

iii. analogy as an instructional strategy should be combined with other innovative instructional strategies to remediate all misconceptions held by biology students.

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